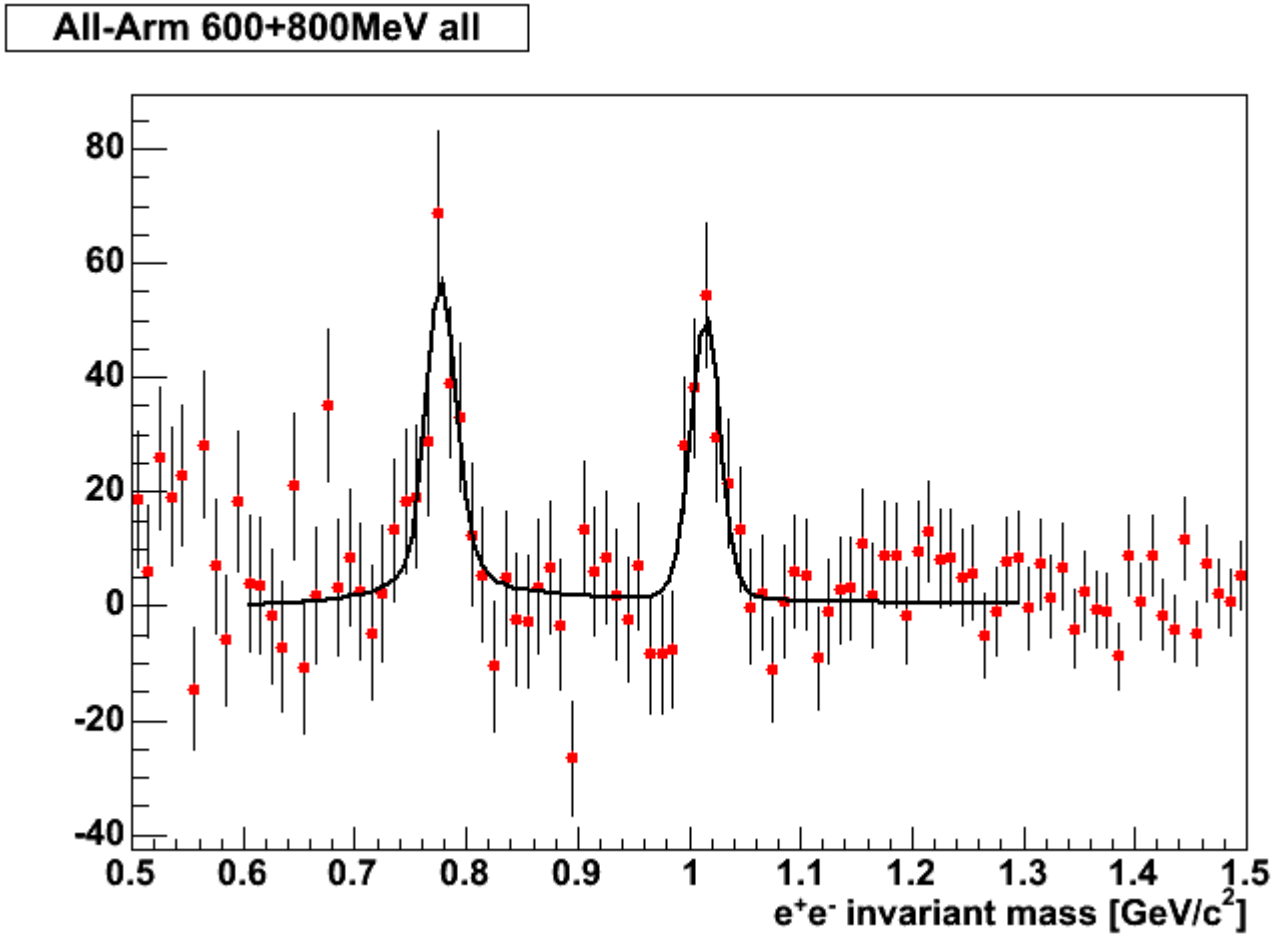
Full data sample – the future



Outlook to the future

Note: early in the story of lmvm ee physics at RHIC

- Near term : this data
  - Use rest of statistics
  - Better control of systematics
  - Centrality dependence (dAu-KK, ee?)
  - omega
- run 4
  - ϕ flow (poster Flow 7: Debsankar Mukhopadhyay)
  - ee in Au-Au 50x run-2
- The far future
  - Upgrades- the Hadron Blind Detector (Cerenkov)
  - RHIC II

Conclusion

dAu $\phi \rightarrow e^+e^-$

dN/dy=.056±.015(stat) ±50%(syst)

T=326 ±94(stat) ±53%(syst) MeV

dAu $\phi \rightarrow K+K-$

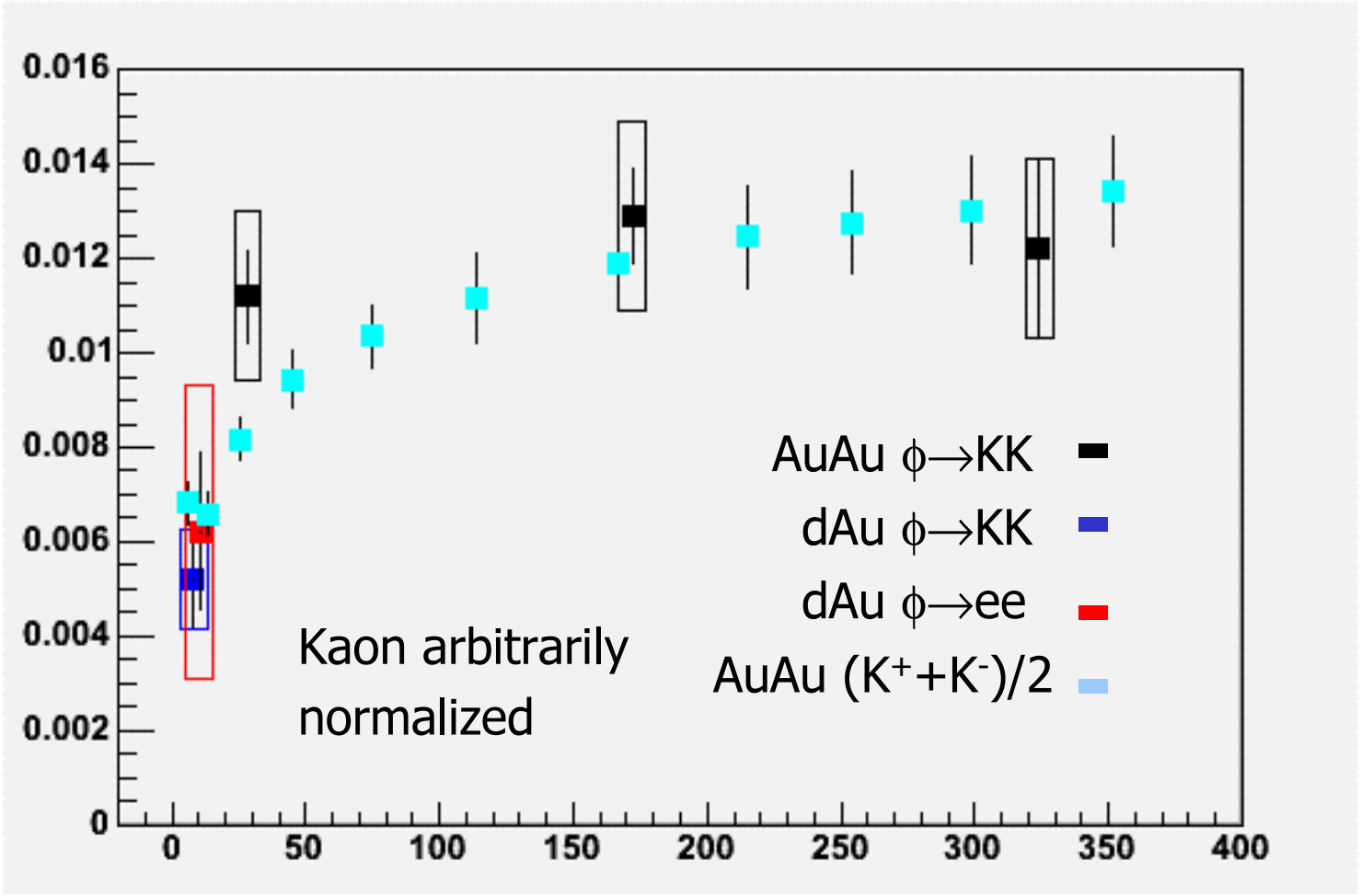
dN/dy = 0.0468 +/- 0.0092(stat) (+0.0095,-0.0092) (syst.)

T (MeV) = 414 +/- 31 (stat) +/- 23 (syst)

- Summary:
  - A first measurement has been made of the ϕ to ee channel in dAu collisions at 200 GeV. Within error bars it agrees with the KK result.
  - For overall shapes in Au-Au ϕ to KK, mass and width stay consistent with PDG as a function of centrality
  - ϕ Enhancement as a function of centrality, similar to kaons

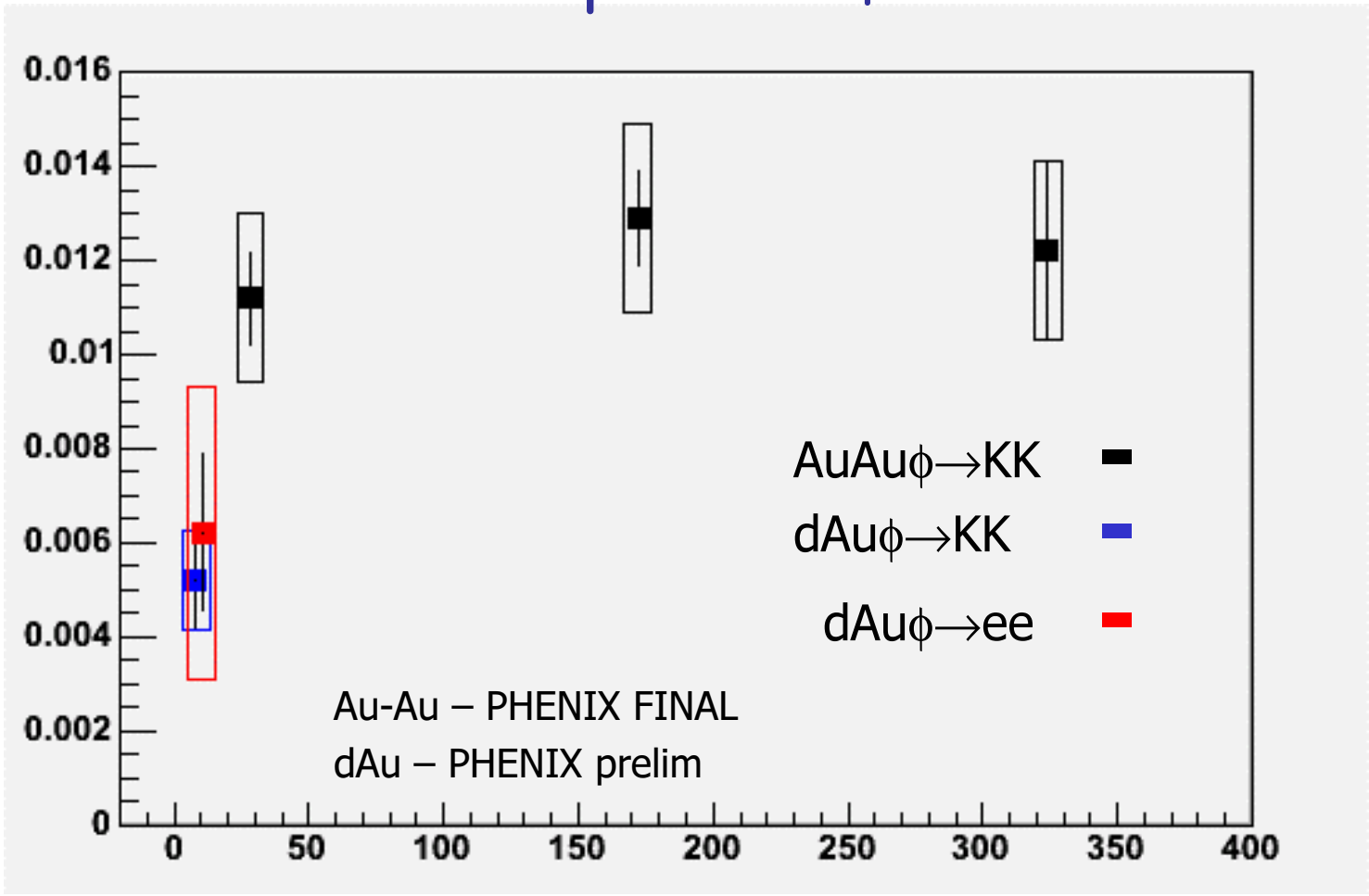
Add kaons

AuAu K – published (nucl-ex/0307022)
Au-Au phi to KK– PHENIX FINAL
dAu – PHENIX prelim



dN/dy rises than seems to saturate as do the kaons

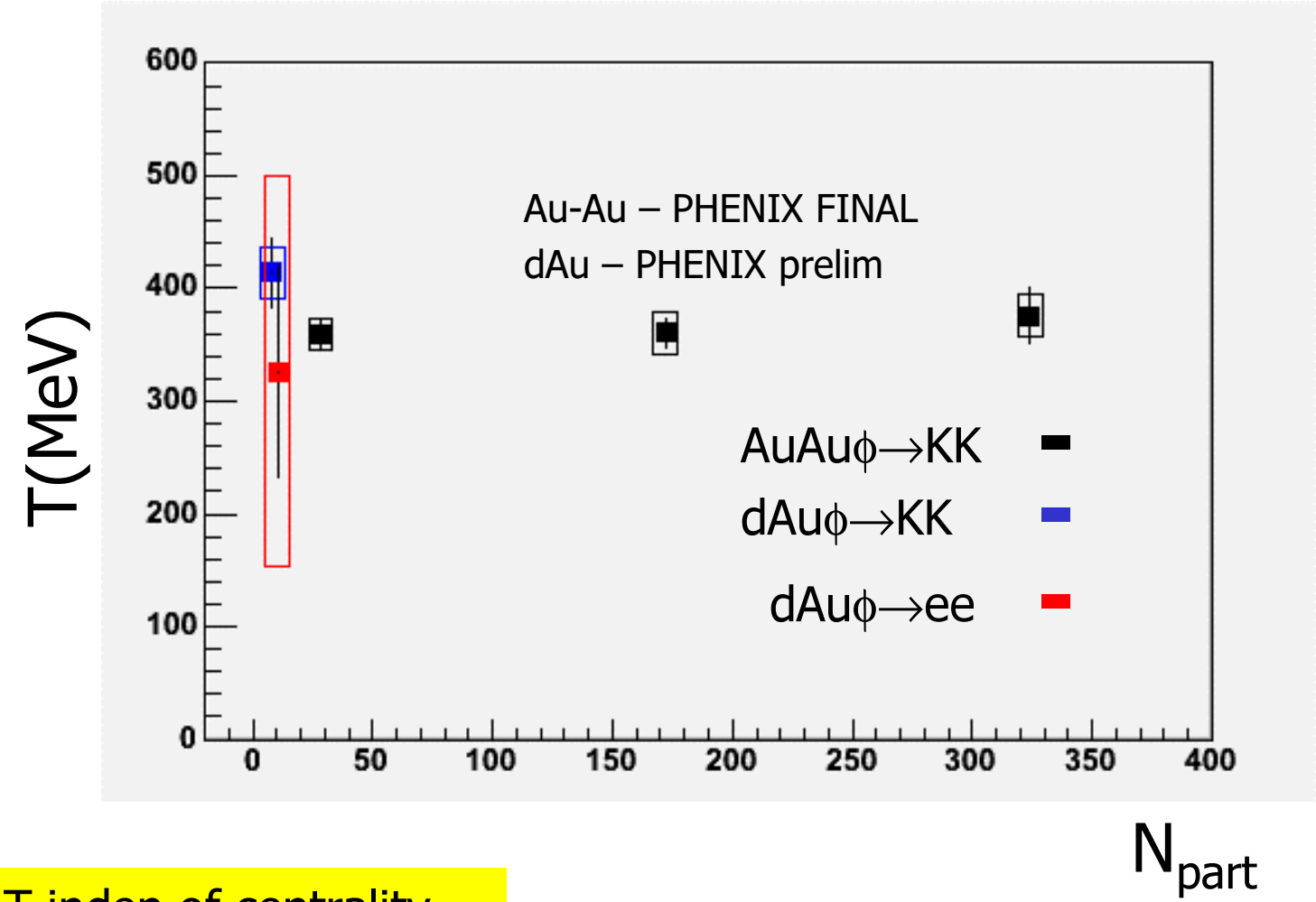
dN/dy per N_{part} (N_{part}~9)



dN/dy rises than seems to saturate

N_{part}

N_{part} dependence of T



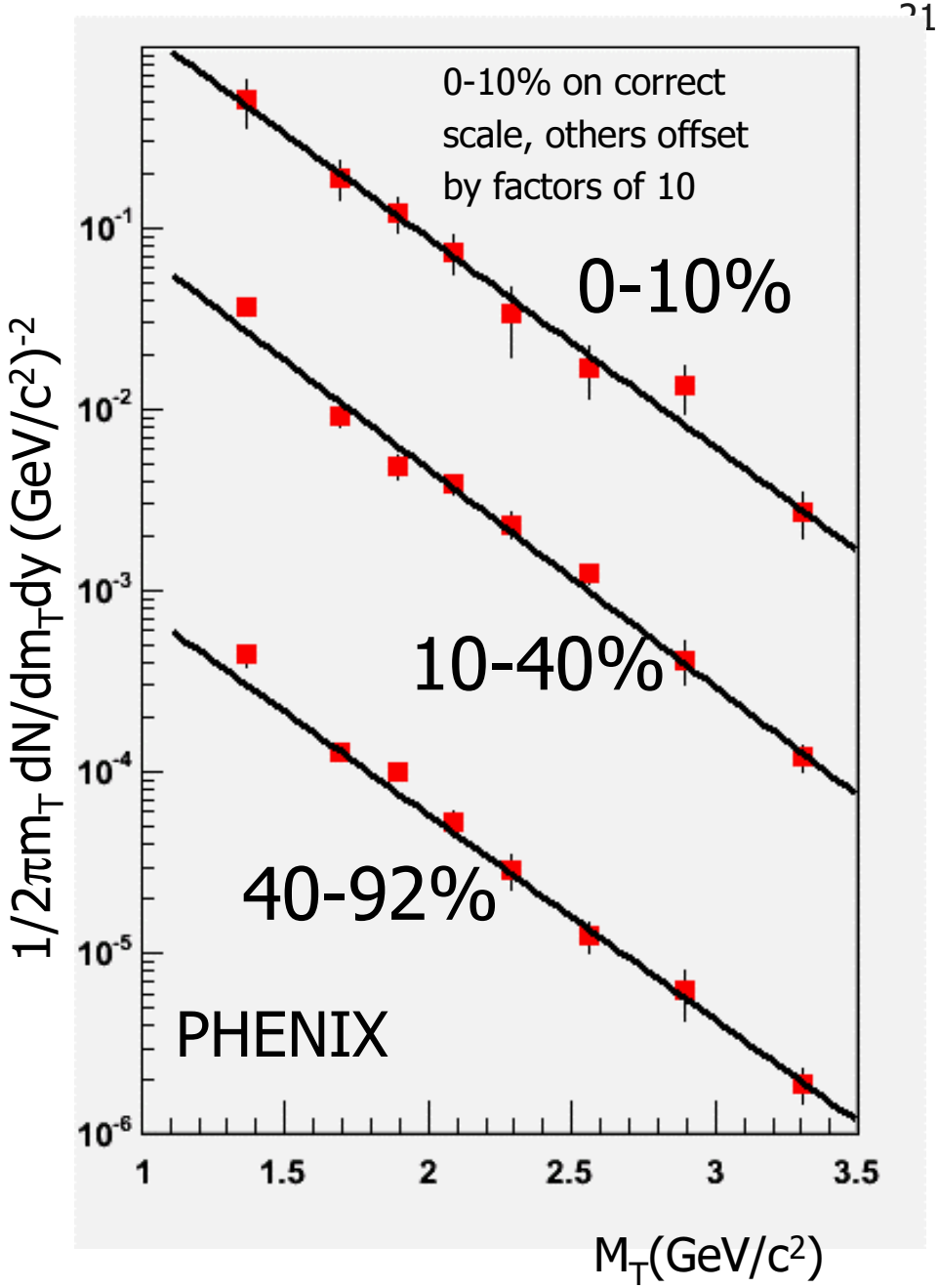
T indep of centrality

AuAu $\phi \rightarrow K^+K^-$

Yields and slopes:

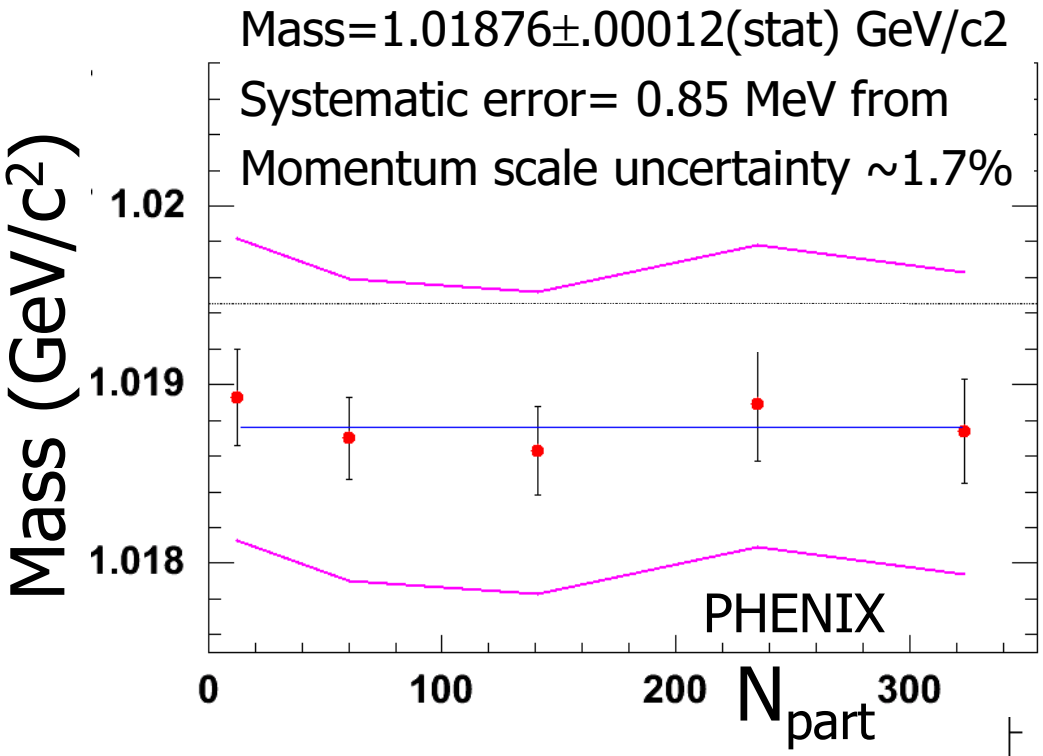
Centrality dependence

Min bias
dN/dy=1.34±0.09(stat) ±0.20(syst)
T=366 ±11(stat) ±18(syst) MeV



more standard fare:

Yields and slopes in dAu and AuAu



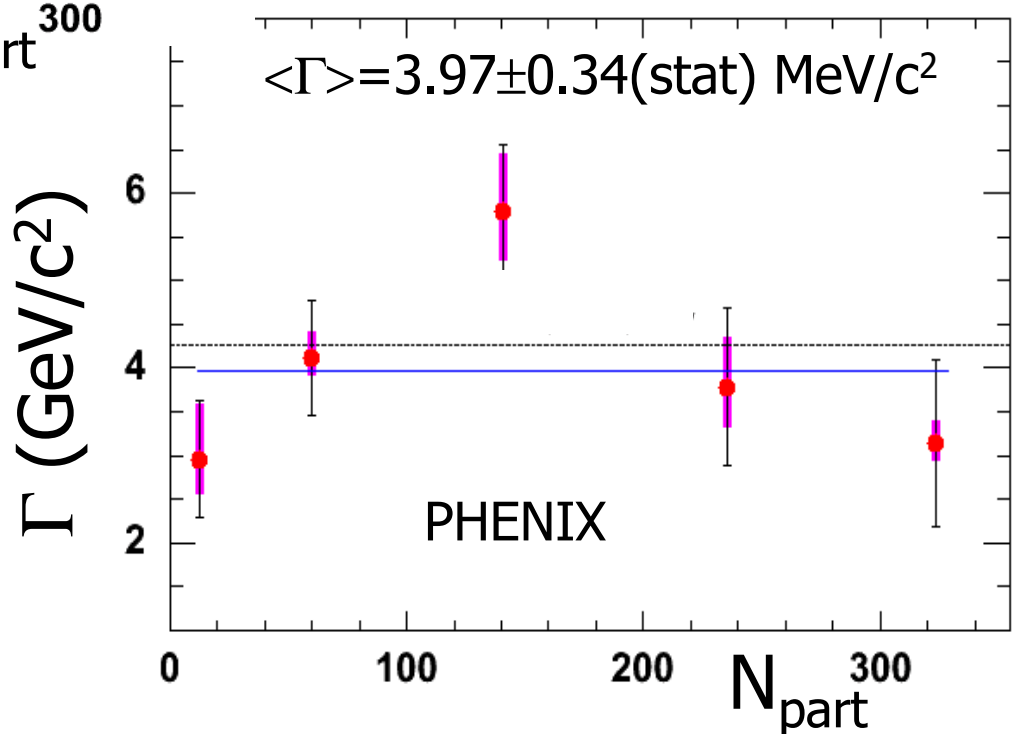
- Mass consistent with PDG
  - independent of centrality-
- Width consistent with PDG
  - Independent of centrality
- Note: $\phi \rightarrow KK$ decaying in fireball - scattered out of peak

$\phi \rightarrow KK$ Au-Au 200 GeV

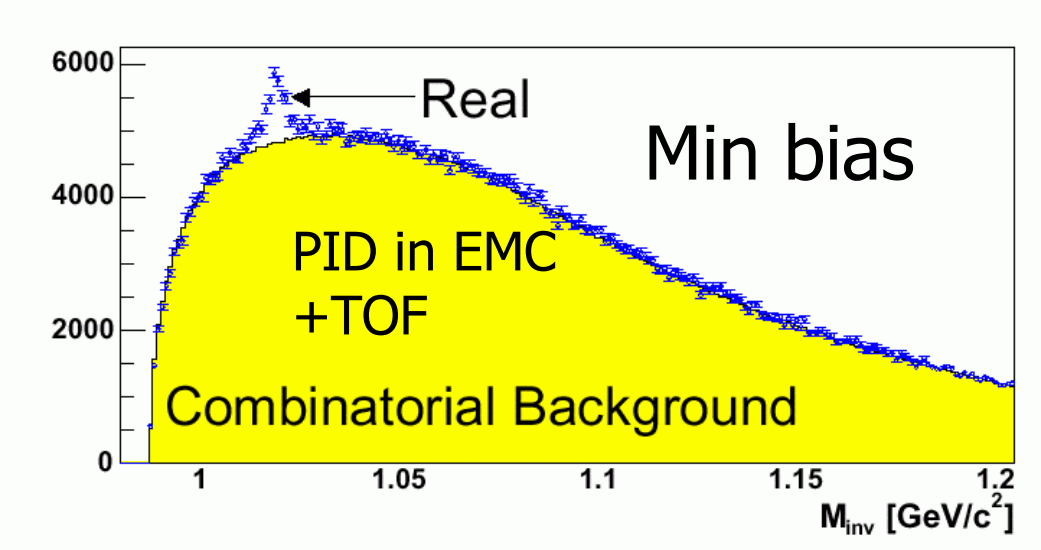
Dependence of mass and width on centrality

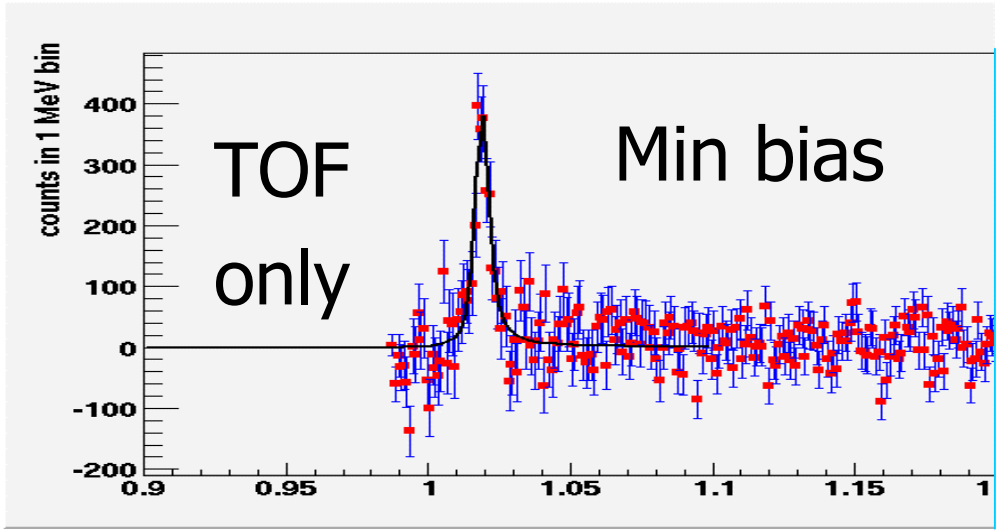
PDG M=1.01946 GeV/c^2

Γ= 4.26 MeV/c^2



Au-Au ϕ to KK





- study the mass and width as a function of centrality
  - Fit to Relativistic Breit Wigner convoluted with a Gaussian experimental resolution
    - σ=1.2 MeV from MC

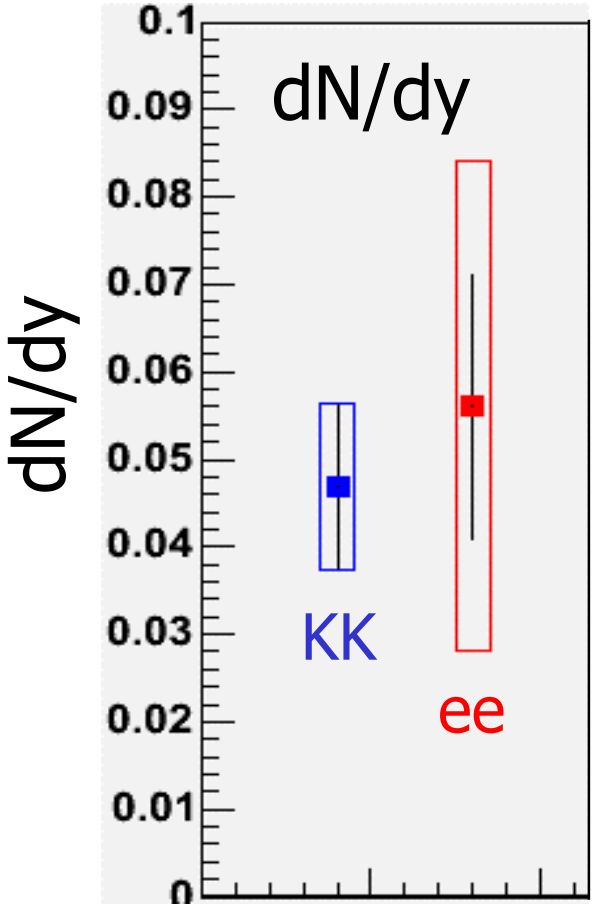
Poster: Strange 14
Charles Maguire

Au-Au collisions: ϕ to KK mass and width dependence on centrality

Compare ee with KK results

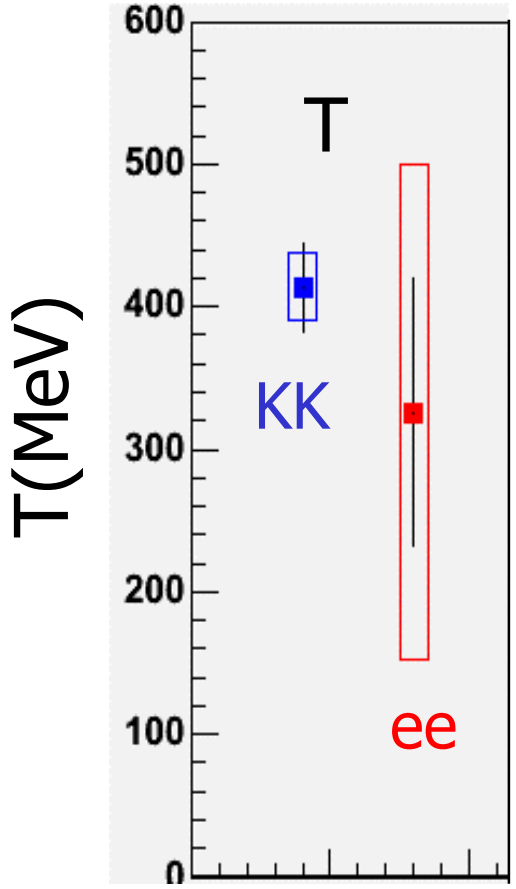
KK channel
dN/dy = 0.0468 +/- 0.0092(stat)
(+0.0095,-0.0092) (syst.)

ee channel
dN/dy=.056±.015(stat) ±50%(syst)



KK channel
T (MeV) = 414 +/- 31 (stat)
+/- 23 (syst)

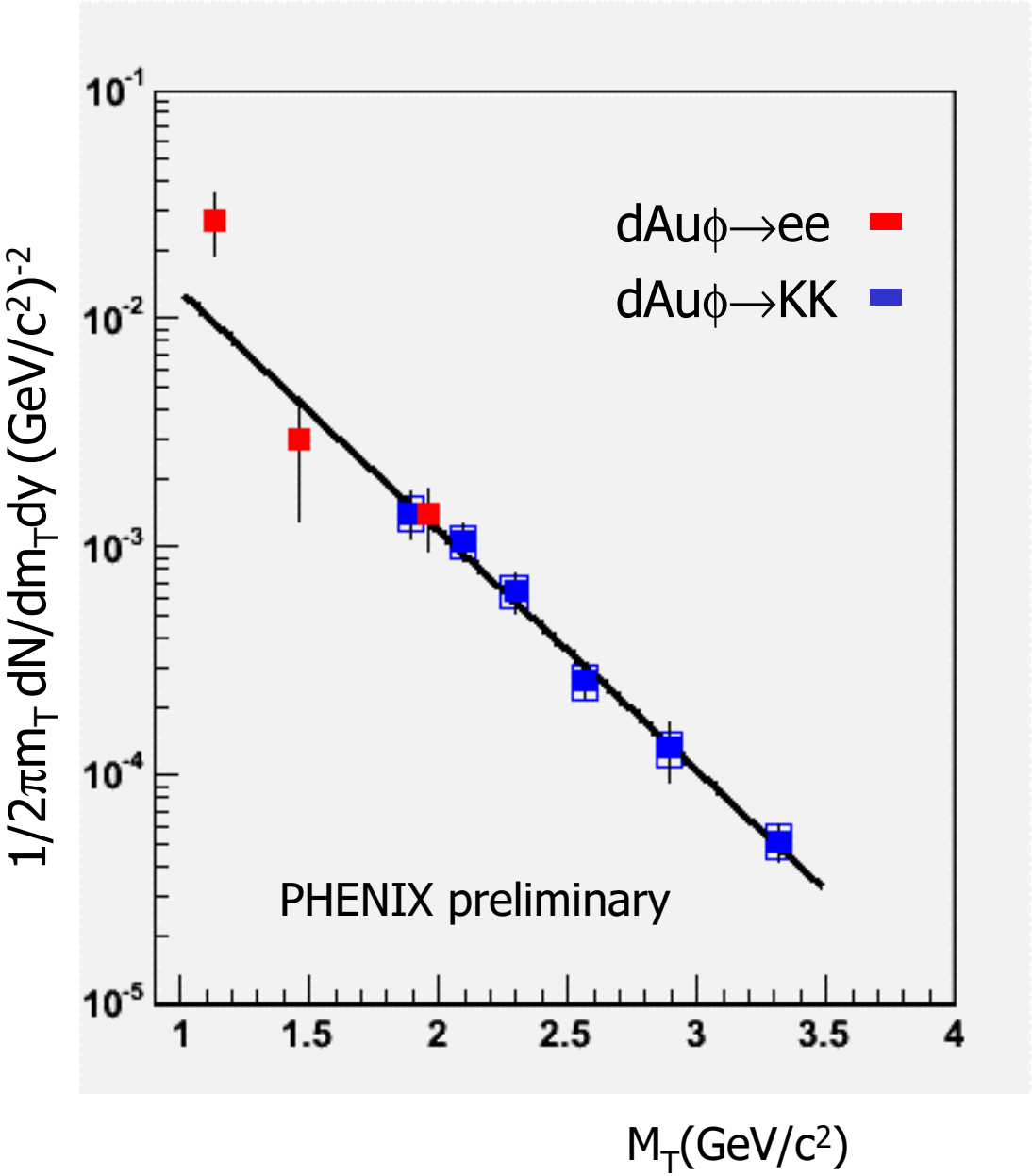
ee channel
T=326 ±94(stat) ±53%(syst) MeV



- Yields consistent with each other
  - BR in normal ratio

PHENIX
preliminary

Minimum-bias m_T distribution of ϕ



ϕ→KK min bias

dN/dy = 0.0468 +/- 0.0092(stat)
(+0.0095,-0.0092) (syst.)

T (MeV) = 414 +/- 31 (stat)
+/- 23 (syst)

(PHENIX preliminary)

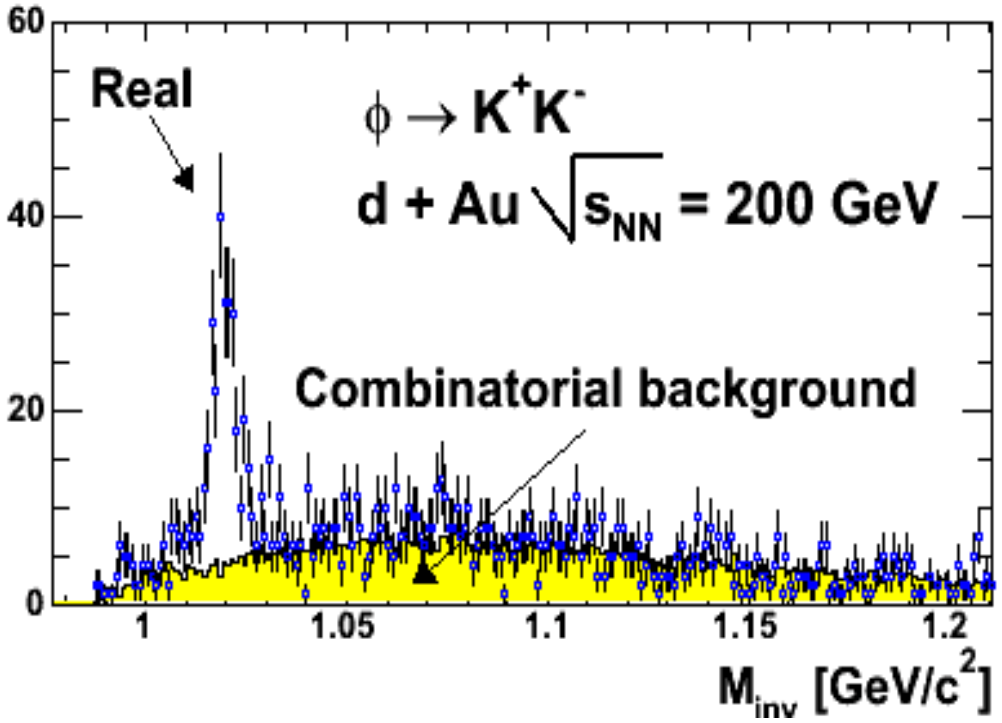
Overall fit
dN/dy~ .0485
T~408
χ^2/DOF=6.7/7

200 GeV dAu – K^+K^- invariant mass

- PID in TOF only (smaller acceptance)
  - Higher pt
- Nevt = 62 M
- Min. bias

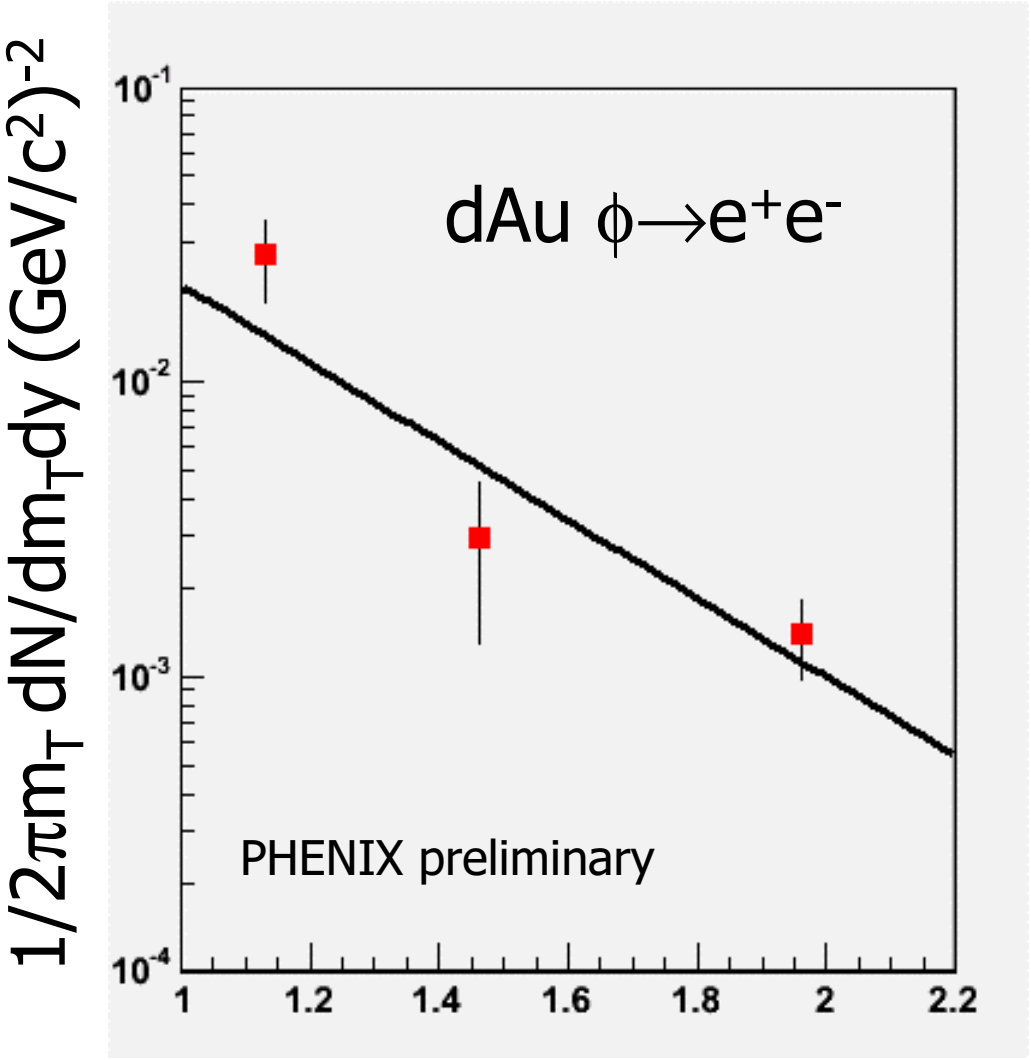
- Fit to Relativistic BW convoluted with a Gaussian
  - N = 207 ± 16
  - S/B ~ 5/1
  - m= 1.0193 ± 0.0003 GeV/c^2
    - Momentum scale error ~1%
  - Γ= 4.750 ± 0.67 MeV/c^2
  - σ=1.2 MeV (fixed)

  - PDG M=1.01946 GeV/c^2
    Γ= 4.26 MeV/c^2



Poster: Spectra 9
Dipali Pal

dN/dm_T and yield



dN/dy=.056±.015(stat) ±50%(syst)

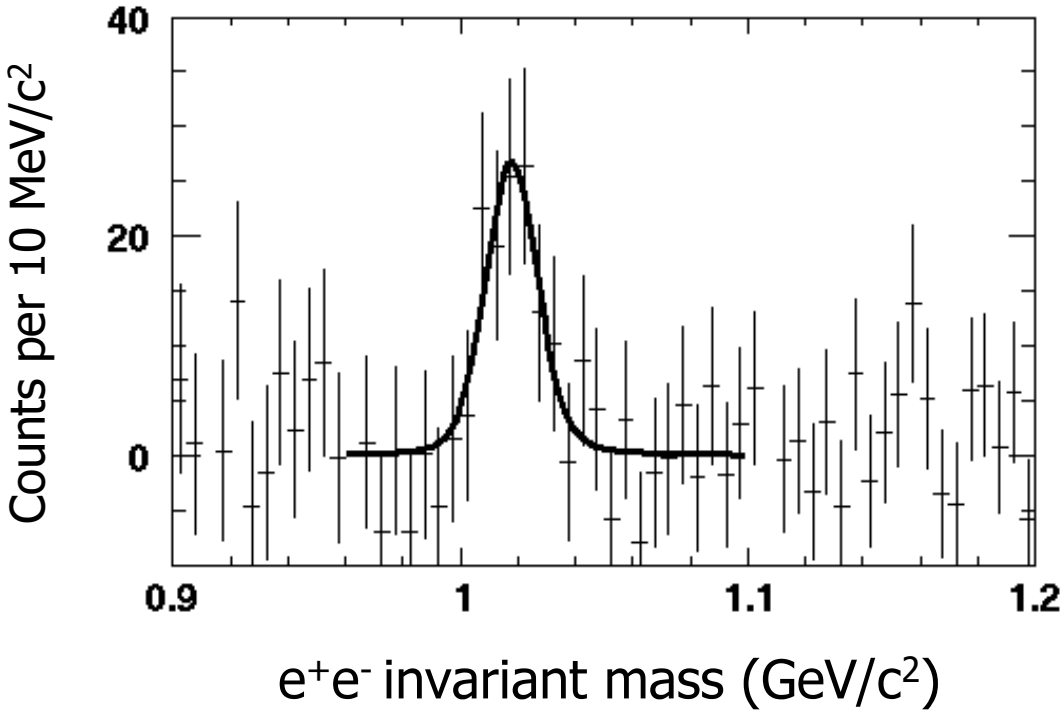
T=326 ±94(stat) ± 53%(syst) MeV

(PHENIX preliminary)

- major contributions to the systematic error
  - normalization of the background and signal extraction and the way the variations affect T and hence dN/dy
  - run-by run variation from the Electron-RICH-Trigger

ee Invariant Mass Spectra 200 GeV dAu- all m_T

- N_ϕ~120
- Fit is to relativistic B-W convoluted with Gaussian
  - M=1.0177 ± 0.0023 GeV
  - Γ=0.00446 GeV(fixed)
  - σ_{exp}=0.0081 ± 0.0021 GeV
  - χ^2/DOF=13.6/13
- Consistent with PDG

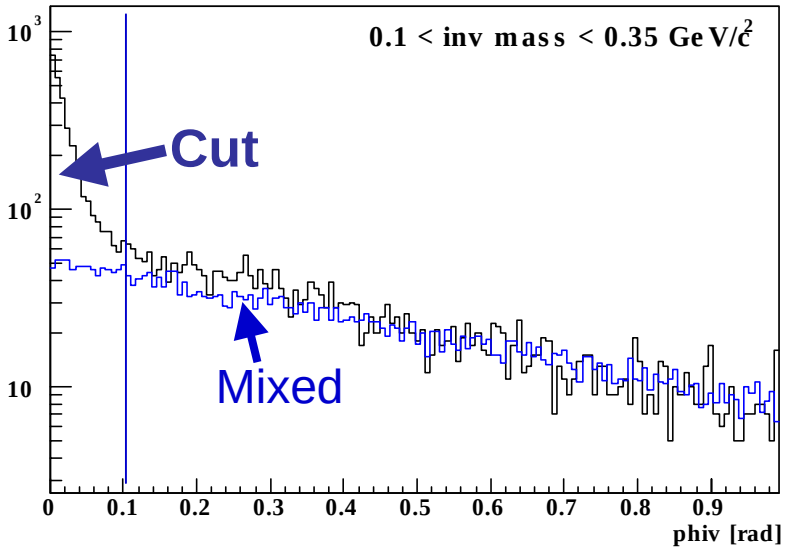


- Now
  - break into 3 m_T bins
  - count signal by summing mass bins ±3σ around mass peak
  - Do corrections and

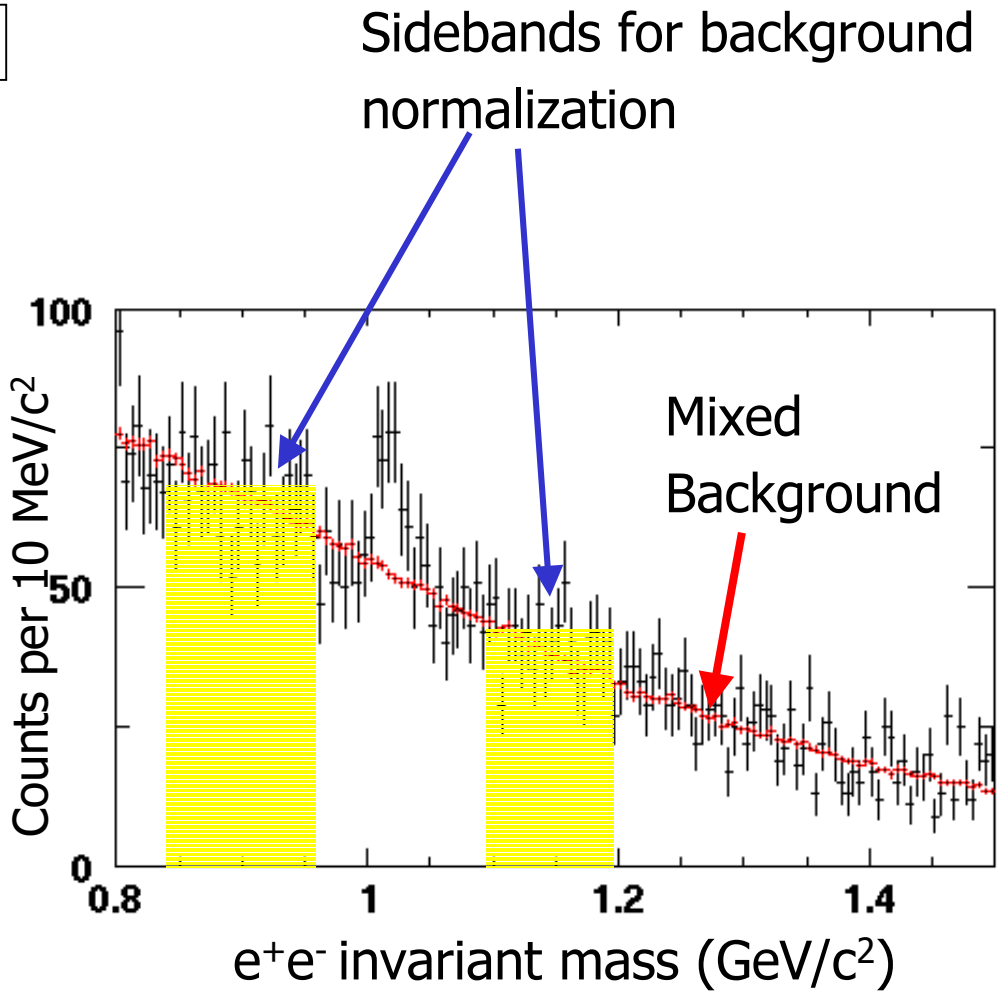
Poster: Electro 4
Yuji Tsuchimoto

Conversion cuts, mixed background

PhiV (100<mass<400MeV)

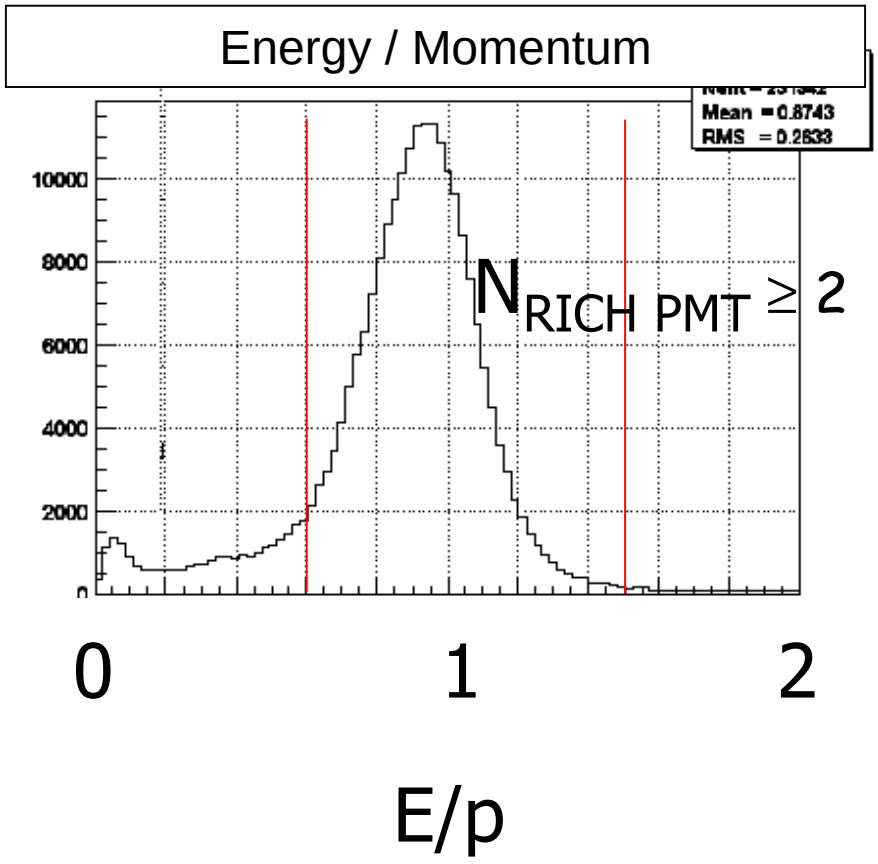


- Rejecting conversions
  - PhiV=Angle plane of pair makes with plane normal to beam direction
    - Zero mass pairs➔PhiV~0
  - Reject conversion pairs if
    - If M_{ee}<100
    - If 100<M_{ee}<400 and phiV<100 mrad



Data sample, electron cuts

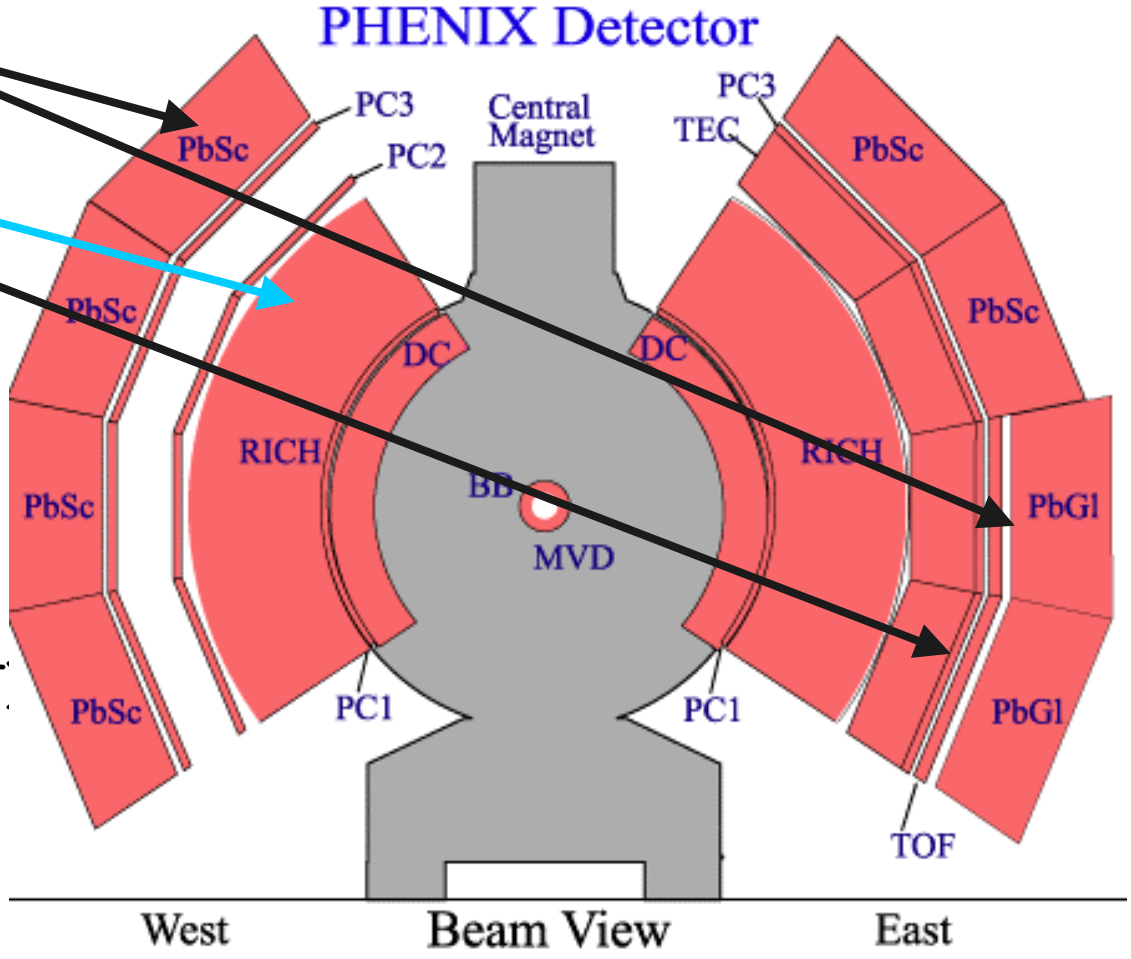
- Analyzed 31M of EMC-RICH-Trigger triggered Events.
  - Corresponds to 1.9G minimum bias
  - 50% of total data taken during run3
  - Threshold > 600 MeV
- Electron PID cuts
  - $N_{RICH\ PMT} \geq 2$
  - 0.5<E/p<1.5
    - E - from EMC
    - P - from tracking



PHENIX– designed for such measurements

- Superb (and redundant) electron PID
  - EMC(PBSc, PbGl)
  - RICH
- PID (for kaons)
  - Via TOF to 2GeV
  - Via EMC to 1 GeV
- Good momentum resolution
- High rate capability
- Triggering capability on electron at Level-1
  - EMC-RICH-Trigger (ERT)
  - Require energy in EMC+RICH firing in coincidence

Need everything working in concert to get a di-electron low mass vector Meson measurement!



dAu Collisions: comparing the

$$\frac{BR(\phi \rightarrow ee)}{BR(\phi \rightarrow KK)}$$

at normal nuclear density
in PHENIX @ RHIC

Let's Look at RHIC (PHENIX)

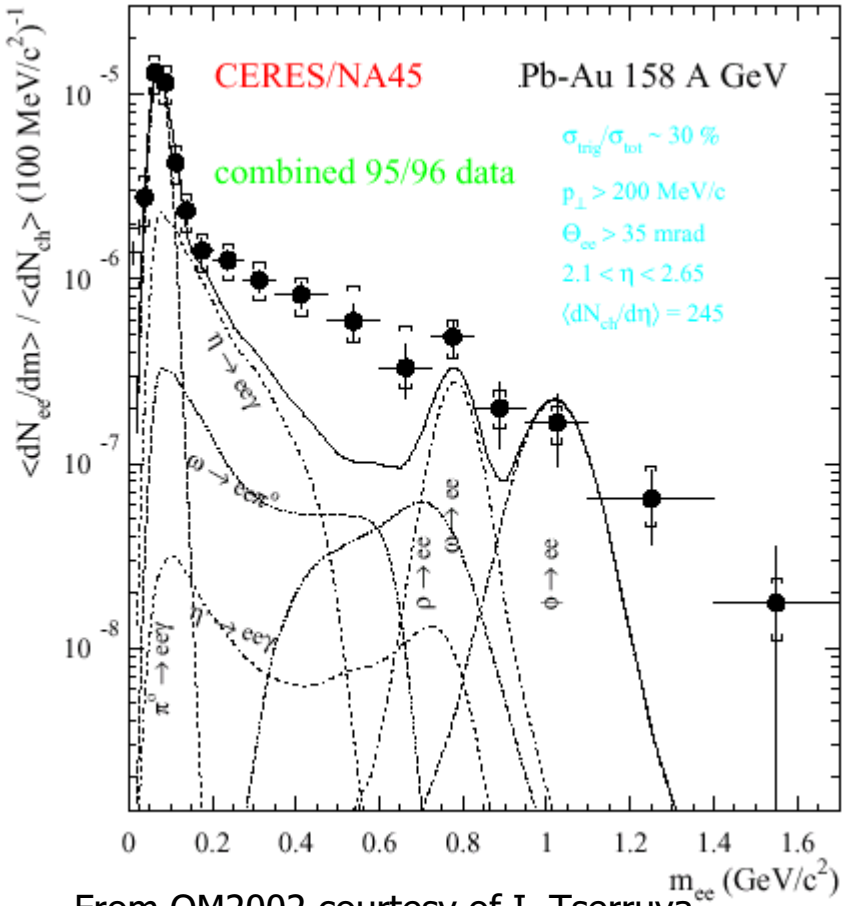
Outline

- Compare BR (normal nuclear density)
  - dAu $\phi \rightarrow ee$
  - dAu $\phi \rightarrow KK$
- Mass shifts/broadening
  - Au-Au $\phi \rightarrow KK$
    - Guess: cannot see this to hadronic decays (only see stuff which decays outside fireball) – or the kaons which do decay and make it out rescatter
- Centrality dependence of ϕ/N_{part}

Note: I will not talk about ϕ R_{CP} – see talk by D. Kochetkov: Friday parallel session 2

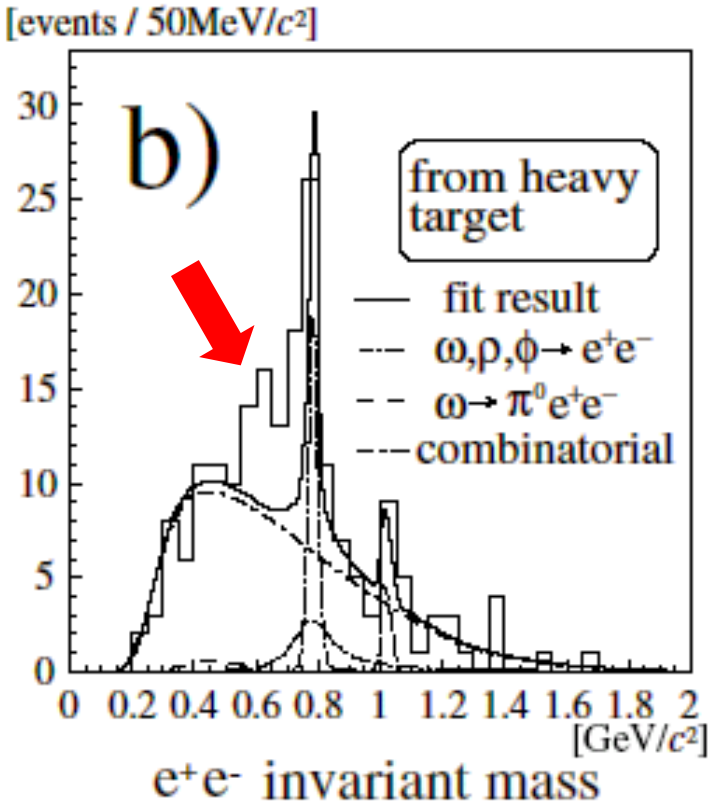
Has anyone seen such effects? e^+e^- invariant mass spectra

- CERES Pb-Au
  - High T vacuum



From QM2002 courtesy of I. Tserruya

- KEK E325 - proton Nucleus
  - "high" baryon density



K.Ozawa et al.

Observation of ρ/ϖ Meson Modification in Nuclear Matter (Phys.Rev.Lett 86-22)

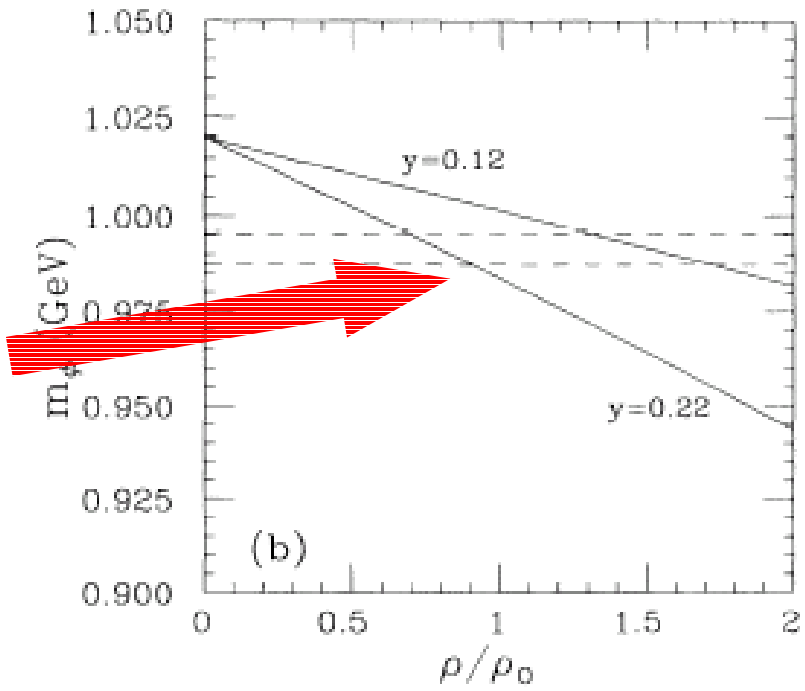
What do we look for?

- Chiral symmetry restored
  - High temperature vacuum – Au-Au Central
  - High baryon density
    - even normal nuclear density.
- Look for
  - Mass shifts/broadening
  - A nice trick:
    - Q value of $\phi \rightarrow KK$ is small

$$\frac{BR(\phi \rightarrow ee)}{BR(\phi \rightarrow KK)}$$

    - Should be sensitive to mass changes in either ϕ or K

Lissauer and Shuryak, Phys. Lett. **B253**, 15 (1991).



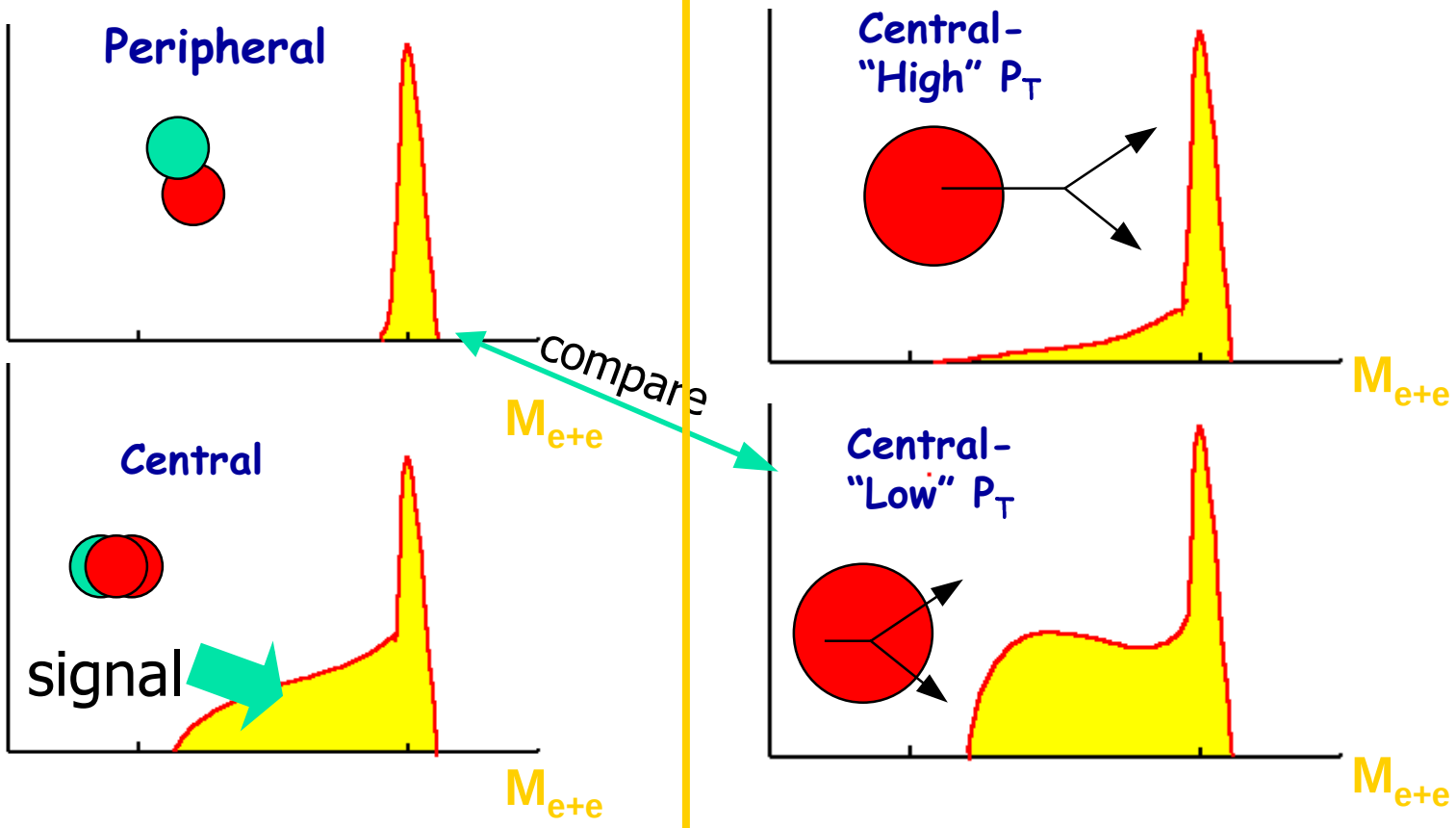
T.Hatsuda and S.Lee

QCD sum rules for vector mesons in the nuclear medium

(Phys.Rev.C46-R34-38, 1992)

Experimental "Knobs"

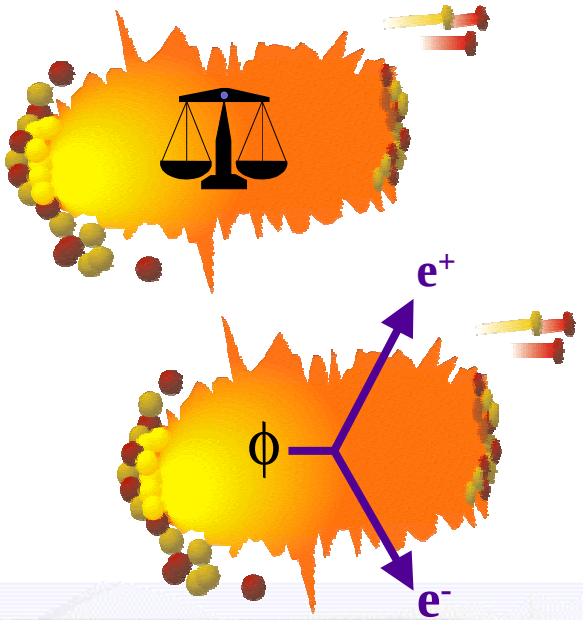
- Signal should increase with centrality
- Signal should increase at low pt



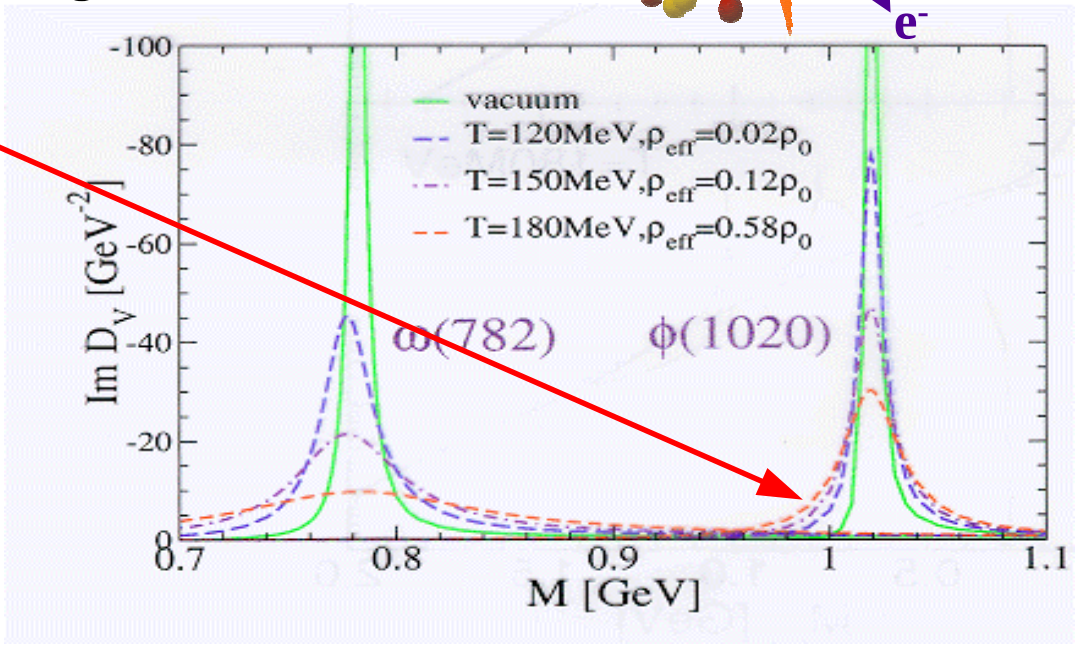
- Today : dAu – min bias only – but there is a "trick"
  : Au-Au – function of centrality

Looking for Chiral symmetry restoration
Vector Meson mass shifts in the dilepton channel

- "Light" Vector mesons (ρ,ω,ϕ)-ideal probes
  - Like putting a scale to measure mass inside the fireball
  - Short lifetime ~ few fm/c
  - ➔ Decay inside hot fireball
- Electrons are ideal messengers
  - Don't interact strongly (e.g. solar ν's)



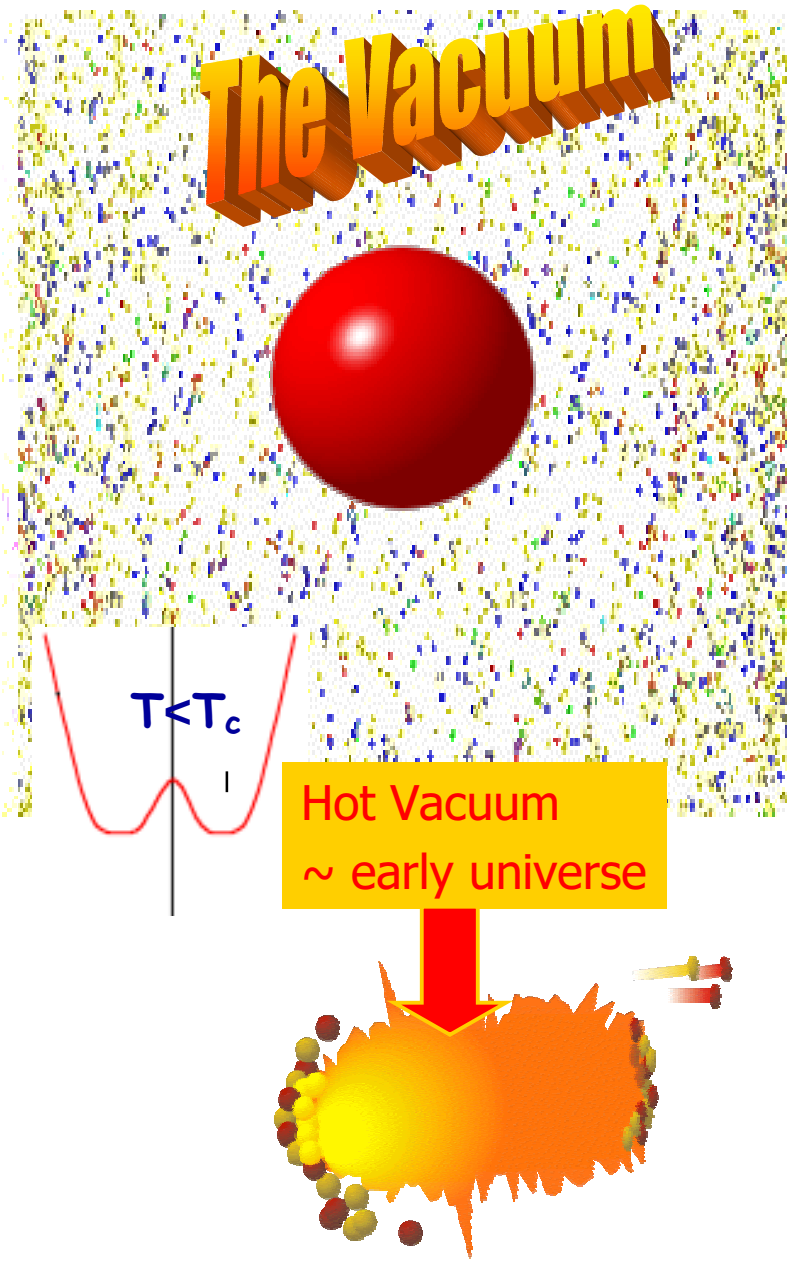
- e.g. In Medium ρ, ω, ϕ
  - shows low mass tail -
    - With its good mass resolution PHENIX should be able to see this



R. Rapp (Nucl. Phys A661(1999) 238c

QCD and the vacuum

- The QCD Lagrangian ~ chiral symmetry (Is it true?)
  - ➔ all masses ~0
- Doesn't match the world we know
- What do we do?
  - Assume the vacuum is not empty – it full of stuff (the "condensate")
  - The interaction with the vacuum gives rise to mass
  - Condensate is Temperature dependent
    - I.e. at high T all masses ~ 0
- Crazy!? Can we test this idea?
- Heat up the vacuum in RHIC collisions
  - we boil it - and see if masses change go to zero ultimately
- Chiral phase transition
- Any connection to deconfinement??



Light vector mesons (ϕ) from dAu in PHENIX

Richard Seto
University of California, Riverside
for the PHENIX Collaboration
Quark Matter 2004
January 13, 2004